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The Effects of Resistance Exercise and Its Prevention of Neurodegeneration

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Abstract

One of the growing problems for people, especially in the elderly community is neurodegeneration, cognitive impairment, and dementia. These cases are expected to continue to rise while diseases such as Alzheimer's disease have no cure. Several studies have examined resistance exercise as a method of improving the outcomes for people with these symptoms. It has been found that resistance exercise is capable of reducing or improving the structural changes of neurodegeneration which leads to cognitive improvements. This review will examine several of these articles and compile them into a format which displays that resistance exercise can be a valuable option to incorporate into a health care plan.

Introduction

It is well documented that the human body begins to deteriorate over time and the brain is no exception to this phenomenon. Healthy adults above the age of 59 years old can lose as much as 5.4 cm^3 per year of total brain volume (1). This loss of tissue can be associated with impaired brain functions such as memory, cognition, coordination, and brain biochemistry. Neurodegeneration occurs for white and gray matter, paired with a consistent increase in ventricle size and cerebrospinal fluid (CSF) volume leads to the loss of brain tissue. The following images display areas of the brain that are particularly susceptible to tissue loss. The areas surrounding the ventricles and the regions located between the ventricles and the skull can be noted as the most susceptible regions of the brain.

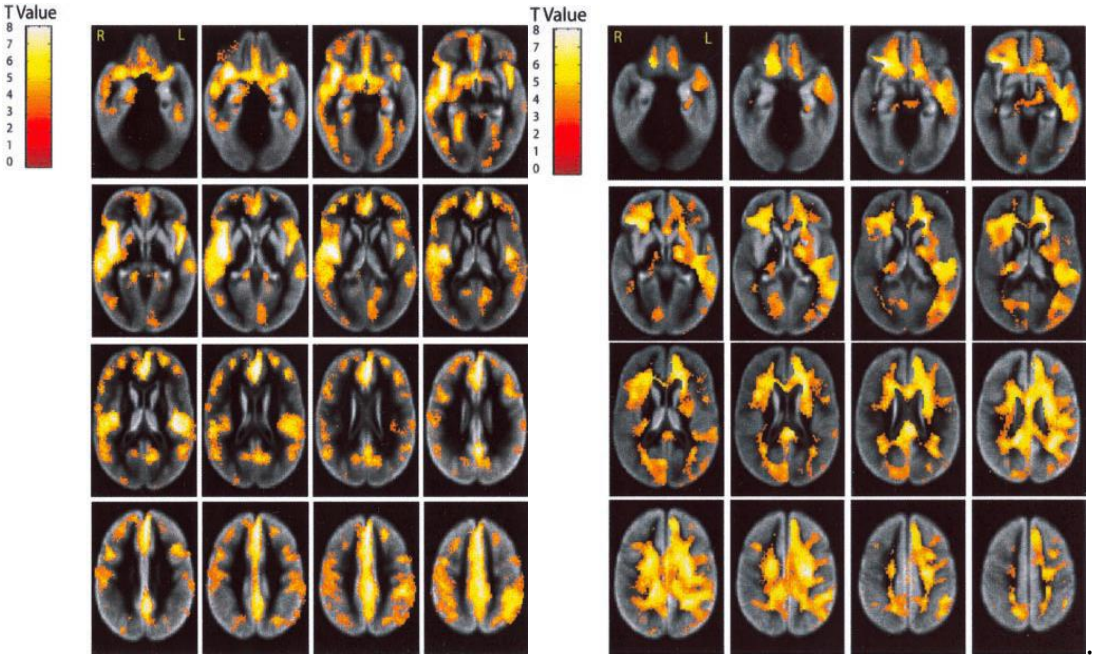

Figure 1. Imaging highlighting regions of gray matter (left) and white matter (right) susceptible to neurodegeneration. Brighter regions indicate areas of more concentrated tissue loss. (1)

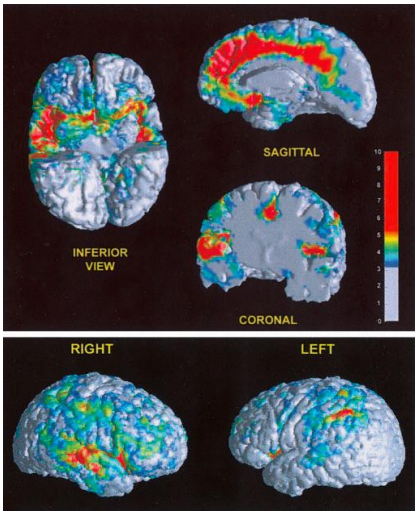

Figure 2. Specific regions of gray matter loss due to neurodegeneration and increased ventricular volume. (1)

Structural changes in the brain such as neurodegeneration and ventricular volume increases are associated impaired cognitive function. Some of these changes can lead to further complications such as dementia. Currently there are around 50 million cases of dementia in the world which makes up about 6% of adults over the age of 60 years old (7). These statistics are projected to increase to about 82 million in the next ten years. Age is the number one risk factor for dementia, but there are several other factors that can contribute to the onset of the disease. Obesity, smoking, nutrition and exercise are all variables that can play a role in the onset of cognitive impairment or dementia. This review will examine resistance exercise and its ability to prevent or improve cognitive function especially for older individuals.

Article Review

Cognitive function involves multiple areas of the brain and their capabilities of processing, integrating, and storing information. This includes attention, learning, memory, and executive function which is a mental process using several cognitive processes which help guide behavior, prioritize tasks, and predict outcomes of potential actions. Declines in the function of these processes are associated with structural changes, particularly in the hippocampus and the prefrontal cortex. Studies show that reversing the structural changes of these areas may be associated with reversing the negative cognitive effects of these changes (5).

Evidence suggests that resistance exercise can improve cognitive function and delay the loss of brain matter. Some potential causes of brain matter loss include hypertension (2) which causes pressure exerted on the tissues and can particularly increase ventricular volume. Several factors can affect cognitive function. Obesity, for example, is one of the most prevalent health concerns in today's society and it has shown a link with cognitive impairment (4). This may be caused by insulin resistance that often accompanies obesity. Studies have found that obesity may cause cognitive deficits as early as childhood or adolescence compared to individuals in the same age range who are not obese (8). Self-control, working memory, cognitive flexibility, planning, and verbal fluency were all negatively affected by obesity as well (8).

Obesity and hypertension cause cognitive impairment and more rapid loss of brain mass respectively. Each of these factors can be improved through regular physical exercise. Exercise offers a proactive approach to reducing risk factors associated with cognitive impairment as well as a direct improvement on cognitive function. In terms of the examination of exercise as it relates to brain function, there has been considerably more research conducted on aerobic exercise than resistance training. While aerobic exercise has been shown to significantly increase the size of the hippocampus (3), it would be a mistake not to consider all possibilities for improving brain health for all individuals. Resistance training is an exercise method of muscle contractions against an opposing force typically using anaerobic respiration as an energy source. This is an inexpensive and easily accessible method of treatment that everyone is capable of performing to some extent due to the many different actions that can be performed under these parameters. A benefit of resistance training for exercise treatment is that it can be prescribed to the patient's individual capabilities. Under the supervision of a health professional or certified trainer, resistance exercises can be used as a controlled method of improving brain health in the later stages of life.

Resistance training is hypothesized to have multiple levels of effects on the brain and cognitive abilities. Level one is at the molecular level with alterations in levels of lactate, IGF-1, TNF-α. This also includes benefits such as reduced inflammation which supports healthy biochemical function of the brain and body (4). Level two is a structural or functional change that can take place from the resistance exercise. These changes would include the neural connections and reversal of the loss of brain tissue. Level three is a larger scale change including decreased stress, better sleep, better moods, and reduced pain. Combining the effects from these three levels leads to overall benefits in cognitive functions such as executive action and memory (5).

Resistance training regimes are most often composed of sets of repetitions applied to multiple muscle groups. For example, a common resistance workout would be 3 sets of 10-12 repetitions for a total of 30-36 repetitions (5). This process would be repeated for multiple muscle groups such as squats, bicep curls, and dumbbell rows. Another aspect to be considered is the load of resistance for each repetition. For capable participants, a one-repetition maximum (ORM) is established as the maximum weight that can be lifted one time. This value is used to calculate the weight that can be used for the exercise program for that individual. For a workout program that consists of 3 sets of 10 repetitions, a weight of 50-80% of the ORM sets the parameters for weight of the resistance. Furthermore, the frequency of workouts is typically set at 1-5 days/week depending on the abilities of the participant. Table 1 outlines a resistance exercise program used by Suo et. al. in a study examining structural and functional mechanism changes in the brain using resistance training as a therapeutic strategy.

Repetition range	Load	Exercises	Frequency	Duration
5-6 exercises of 3 sets of 8 repetitions	80-92% of ORM	Leg press, chest press, seated row, hip (abduction, flexion, extension), lateral raises and triceps extensions	2 days per week	26 weeks

Table 1. An example of a resistance training program representative of many common programs used for examining the effect of resistance exercise on cognitive abilities (6).

In this particular study, it was found that resistance exercise improved the cortical thickness of participants. This structural change led to the ability to improve on cognitive testing (6). This supports the idea that resistance exercise can improve cognitive abilities as well as prevent/reverse neurodegenerative loss.

In a separate study using mice with Alzheimer's disease, researchers examined the mice's ability to complete a maze course, recognize novel objects, and an open field test. The training method used was to have the mice climb a 1m ladder. For mice in this experimental group, weights of 15, 30, 50, and 75% of their body weight. This exercise was performed on an alternating day schedule for a span of four weeks. Each session, mice were motivated to climb the ladder 15 times (9). Mice cognitive abilities were assessed by placing them in a Y-shaped maze where they had to find the location where an electric shock could be avoided. Mice who participated in resistance training made significantly fewer errors and completed the task in a significantly shorter amount of time (9). A Western blot and staining of the brain tissues was performed which found that there was an increased expression of synaptic proteins in the mice brains. It was also found that resistance exercise reduced the number of amyloid plaques in the brain (9). The reduction of plaques is a promising result because they are one of the most indicative signs of Alzheimer's disease. This research strongly supports the idea that resistance exercise is capable of causing structural changes that improve the cognitive abilities of the individual. This research is also promising due to the fact that there has not been an effective treatment for slowing or improving the effects of Alzheimer's disease. This finding is promising because resistance exercise is a cheap and accessible method of treatment that may be capable of improving the onset and outcomes of the disease.

The previous studies indicate that resistance exercise is capable of inducing structural and functional changes in the brain. In most cases however, the population that this treatment will be aimed at is elderly individuals. It is likely that typical weight training methods will not be feasible due to the risk of injury in this age group. A study that was aimed at the elderly population was conducted by Tsuyuguchi et. al., to test a training method that could be more easily performed by the people in this age group. To perform the study, 35 nursing home

residents were given a Mini-Mental State Exam (MMSE) to determine a baseline for cognitive abilities. The resistance training method used for the experimental group was a toe-grip exercise which consisted of pulling a towel towards the subject by curling their toes. It was hypothesized that this movement would be a sufficient exercise because it is a movement involving muscles that many of the residents do not often work. These exercises were performed three times per week over a twelve-week span (10).

The results of this study indicated that the toe-grip training method was capable of improving the cognitive abilities of nursing home residents. It was found that the experimental group scored significantly higher on the MMSE after the training program. A direct correlation was found between toe-grip strength and improvement on the MMSE (10). These results are important because they support the ability of resistance exercise to be used as a therapeutic mechanism for people of all stages and abilities. A latent result of this study is that the participants in the exercise group improved their balance, and lowered their risk of falls which is a benefit to overall health of this population

Conclusion

Several of these studies have shown that resistance exercise is capable of altering the structural and functional changes in the brain. Some have shown that the training is directly associated with the structural change that leads to the improved cognitive processes. It has also been shown that the training methods can be tailored to fit the needs of the individuals receiving the treatment. Taking these characteristics into consideration, resistance exercise can be used as a therapeutic strategy and should be incorporated into the care for individuals suffering from cognitive deficiencies. Resistance exercise can be incorporated into the lifestyle of almost any person from an early age. Before neurodegeneration takes place, the results of these studies indicate that it could help prevent the onset of cognitive debilitation, leading to improved quality of life and numerous brain health benefits. After neurodegeneration has begun, resistance training could help slow or even reverse the effects that individuals are experiencing.

There are three characteristics of resistance exercise that make it particularly valuable to consider as a treatment method. The first is effectiveness, as shown by the studies examined in this review. Resistance training is capable of improving the cognitive abilities of individuals. Alzheimer's mice displayed fewer amyloid plaques, a result that has not been observed by pharmacological drugs. Its effectiveness is seen in early ages as well as shown by improvements in cognitive abilities for children in the obese category. The second characteristic is accessibility. Resistance training can be a fraction of the price of pharmacological drugs which allows it to be accessed by a much wider range of patients than a drug would be capable of reaching. In many cases, it may cost the patient almost nothing if they have the capabilities and tools to perform the exercises on their own. The third main characteristic that makes resistance exercise a valuable treatment is its ability to be tailored to the exact abilities of the patient. As shown with the study by Suo et. al., a one-repetition-max is established to show exactly the load that the individual can handle for the exercise movements. Likewise, the toe-grip training offers

an answer to how patients can participate in the exercise even if standard resistance training methods are dangerous for them to perform. Another way which resistance training can be tailored to the individual is to combine it with other treatment methods that are being prescribed for that person. Exercise will not interfere with pharmacological mechanisms of medications that the patient is taking, and it can be [aired with other training mechanisms such as cognitive or aerobic training. Because of these three characteristics, resistance training would be a valuable addition to the treatment for individuals experiencing cognitive deficiencies and neurodegeneration.

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